Combined limit for searches for 1st and 2nd generation LQ

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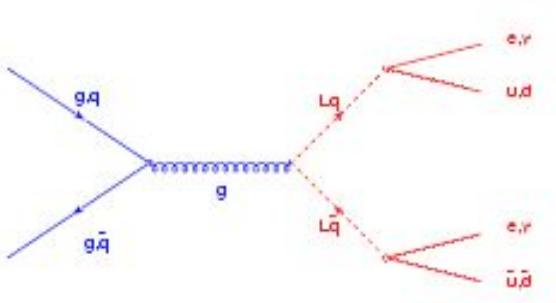
LQ at the TeVatron

- Production
  - qg → LQ + LQbar
  - gg → LQ + LQbar
  - qqbar → LQ + LQbar
- Decay
  - LQLQ → l^+l^-qq, l^+nqq, nnqq



β = Br(LQ->eq)

- Experimental signature:
  - High pt isolated leptons (and/or MET) + jets

LQ search in eejj

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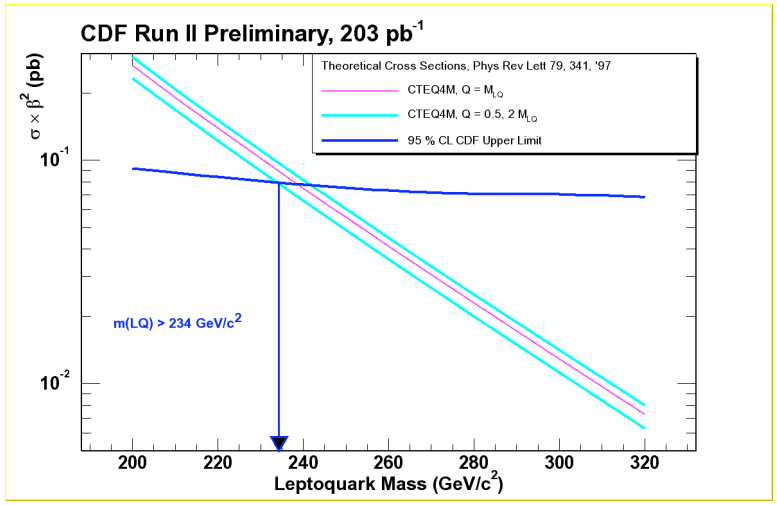
Signature: 2 electrons and 2 jets

Analysis cuts

- 2 central electrons with $E_T > 25$ GeV
- 2 jets with $E_T(j1) > 30$ and $E_T(j1) > 15$ GeV
- removal of events with $76 < M_{ee} < 110$ GeV
- $E_T(j1) + E_T(j2) > 85$ GeV && $E_T(e1) + E_T(e2) > 85$ GeV
- $((E_T(j1) + E_T(j2))^2 + (E_T(e1) + E_T(e2))^2) > 200$ GeV

Number of events observed is
Consistent with background expectation



LQ search in e□jj

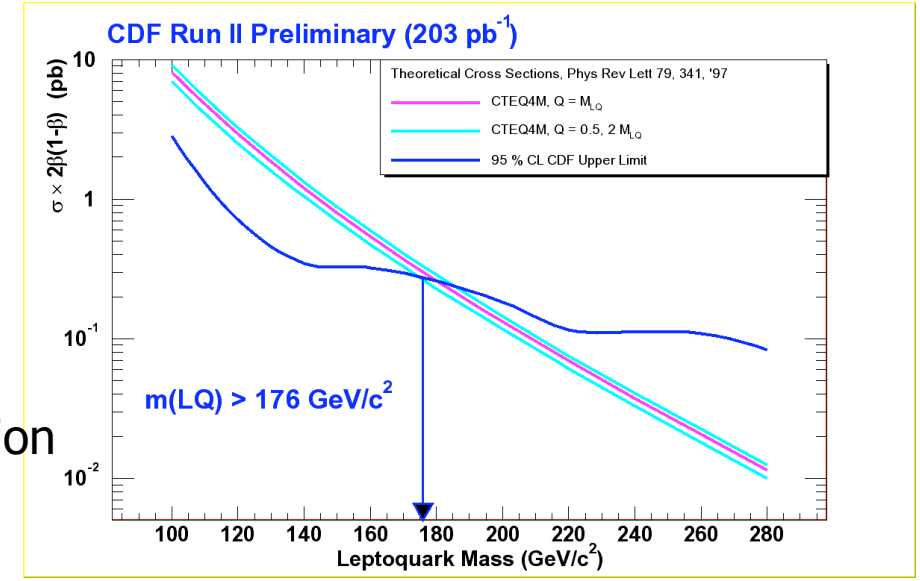
cdf7090

Signature: 1 electron, 2 jets and large MET

Analysis cuts

- 1 central electrons with E_T > 25 GeV and MET > 60 GeV
- 2 jets with E_T > 30 GeV
- □□ (MET-jet) > 10°
- $E_T(j1) + E_T(j2)$ > 80 GeV
- M_T(e-□) > 120
- Mass Cut

Number of events observed is
Consistent with background expectation



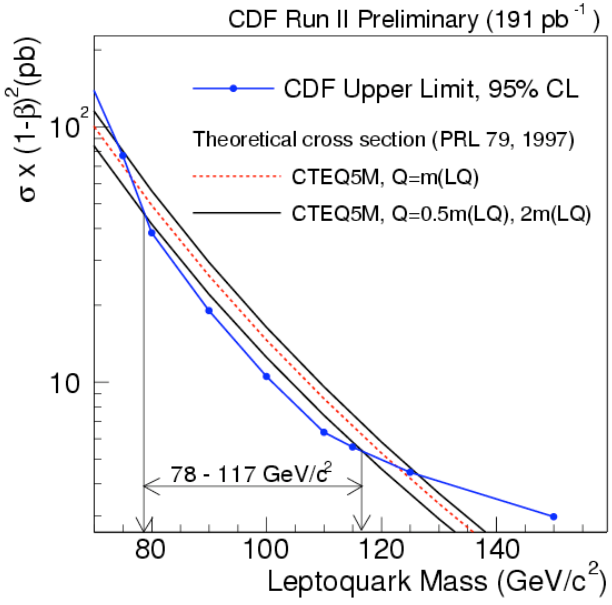
LQ search in □□jj

cdf6593

Signature: Large MET and 2 jets

Analysis cuts

- MET > 55 GeV
- 2 or 3 jets
  - E_T(jet1) > 40 GeV, E_T(jet2) > 25 GeV, E_T(jet3) > 7 GeV
  - $|\eta_{1/2}|<1$; $|\eta_3|<2.5$
  - No other jet with E_T > 7 GeV
- $100^0 < \Delta\phi$ (MET-jet1/2) $< 165^0$
- $80^0 < \Delta\phi$ (jet1-jet2) $< 165^0$
- $30^0 < \min\Delta\phi$ (MET-jet2/3) $< 135^0$
- Lepton veto
- 0.1 < Jet Em Fraction < 0.9
- min # of tracks in jet ≥ 4



Number of events observed is
Consistent with background expectation

Combination method

- Bayesian approach: modification of bayes.f
- Joint likelihood formed from the product of the individual channels likelihood.
- For each mass we simulated 10K pseudo-experiments, smearing the calculated number of background events and the estimated number of signal events by their respective total uncertainties.
- The searches in the eejj and e□jj channel use common criteria and sometime apply the same kind of requirements (for example on the tight electron identification) so the uncertainties in the acceptances have been considered completely correlated (which gives the most conservative limit).
- When calculating the limit combination including also the □□jj channel the uncertainties in the acceptances have been considered uncorrelated.A correlation factor of 0.5 has also been considered (no difference)

$$\sigma_{LIM} = N_{LIM}/(\varepsilon_{average} \cdot \mathcal{L})$$

  - $\varepsilon_{average} = (\varepsilon^2(eejj) + 2\varepsilon(1-\varepsilon)\varepsilon(e\nu jj) + \varepsilon^2(ee \text{ as } e\nu)$) for the 2 channels case and
  - $\varepsilon_{average} = (\varepsilon^2(eejj) + 2\varepsilon(1-\varepsilon)\varepsilon(e\nu jj) + (1-\varepsilon)^2\varepsilon(\nu\nu jj) + \varepsilon^2(ee \text{ as } e\nu)$) for the three channels case.

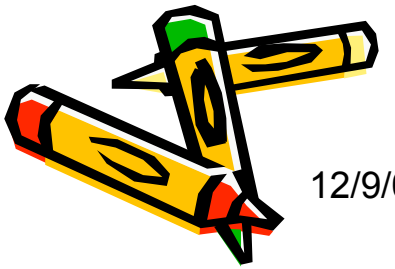
$\mathcal{L} = 203 pb^{-1}$

Acceptances I : eejj

Mass	Acceptance	Relative Error
100	0.027	0.07
140	0.12	0.047
160	0.32	0.042
200	0.35	0.045
220	0.38	0.046
240	0.404	0.042
260	0.42	0.041

Background expected:
6.24 ± 2.16

Data: 4 events



Acceptances II : e□jj

Mass	Acceptance	Relative Error
100	0.017	0.13
140	0.085	0.089
160	0.088	0.088
200	0.165	0.081
220	0.19	0.08
240	0.204	0.079
260	0.22	0.079

Background expected:

Mass	100	120	140	160	180	200	220	240	260	280
W+2 jets	1.5±0.9	1.5±0.9	1.5±0.9	2.5±1.13	2.5±1.13	2.5±1.13	2.0±1.0	2.0±1.0	1.5±0.88	0.5±0.5
top	2.7 ±0.6	3.3 ±0.6	3.12 ±0.5	2.8 ±0.5	2.5 ±0.5	2.03 ±0.4	1.63 ±0.4	1.08 ±0.3	0.8 ±0.22	0.6 ±0.21
Z+jets	0.05 ±0.01	0.05±0.01	0.08±0.02	0.08±0.02	0.08±0.02	0.08±0.02	0.06±0.02	0.06±0.02	0.04±0.01	0.04±0.01
Total	4.3±1.03	4.9 ±1.05	4.7 ±1.1	5.4 ±1.2	5.0 ±1.2	4.6 ±1.23	3.7 ±1.06	3.1 ±1.0	2.3 ±0.9	1.1 ±0.6
Data	**7**	**6**	**4**	**4**	**4**	**4**	**2**	**2**	**2**	**1**

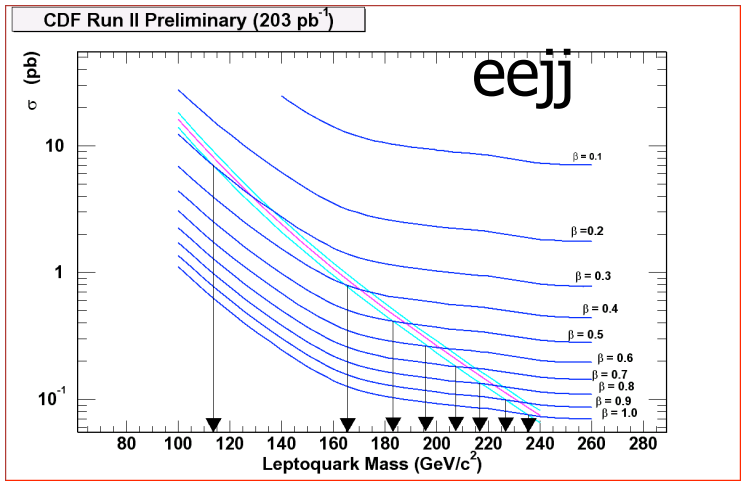
Acceptances III: □□jj

			$\sigma_{\rm NLO}$(pb)	
m_{LQ_1} (GeV/c^2)	ϵ_{LQ_1}	$\delta_{\rm tot}$ (%)	$\mu = m_{LQ_1}$	$\mu = 2m_{LQ_1}$
75	0.0073	29	69.4	58.8
80	0.0113	26	49.2	41.5
90	0.0187	23	26.0	22.1
100	0.0300	20	14.6	12.5
110	0.0431	16	8.4	7.4
115	0.0482	15	6.7	5.8
125	0.0590	15	4.2	3.6
150	0.0828	13	1.4	1.3
175	0.1010	12	0.57	0.51

Source	Events expected
$W(\rightarrow e\nu)$+jets	$6.1 \pm 1.4 \pm 1.5$
$W(\rightarrow \mu\nu)$+jets	$21.7 \pm 2.3 \pm 2.8$
$W(\rightarrow \tau\nu)$+jets	$28.4 \pm 3.8 \pm 4.1$
$Z(\rightarrow \mu\mu)$+jets	$1.1 \pm 0.2 \pm 0.2$
$Z(\rightarrow \tau\tau)$+jets	$0.9 \pm 0.2 \pm 0.2$
$Z(\rightarrow \nu\nu)$+jets	$39.1 \pm 2.8 \pm 3.6$
$t\bar{t}$	$4.3 \pm 0.4 \pm 0.3$
QCD	16.9 ± 6.7
Total Events	118.5 ± 14.5

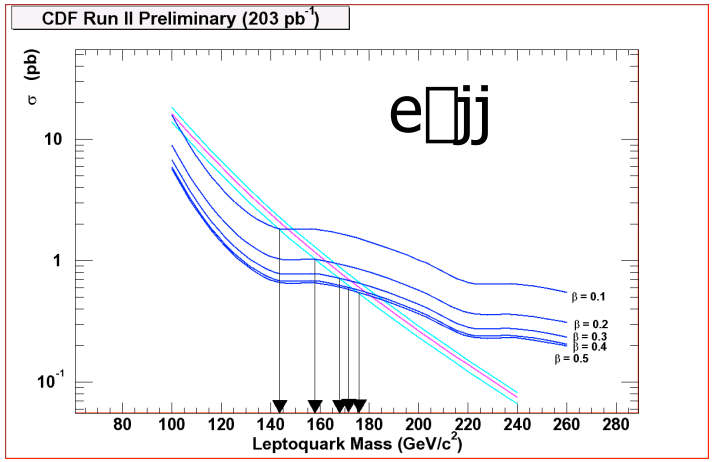
Data : 124

Results: individual channels



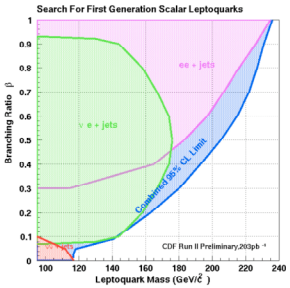
□	mass limit range (GeV/c^2)
0.0	78 - 117
0.01	79 - 116
0.02	80 - 115
0.03	80 - 114
0.04	80 - 113
0.05	84 - 112
0.06	86 - 111
0.07	90 - 110
0.08	not clear

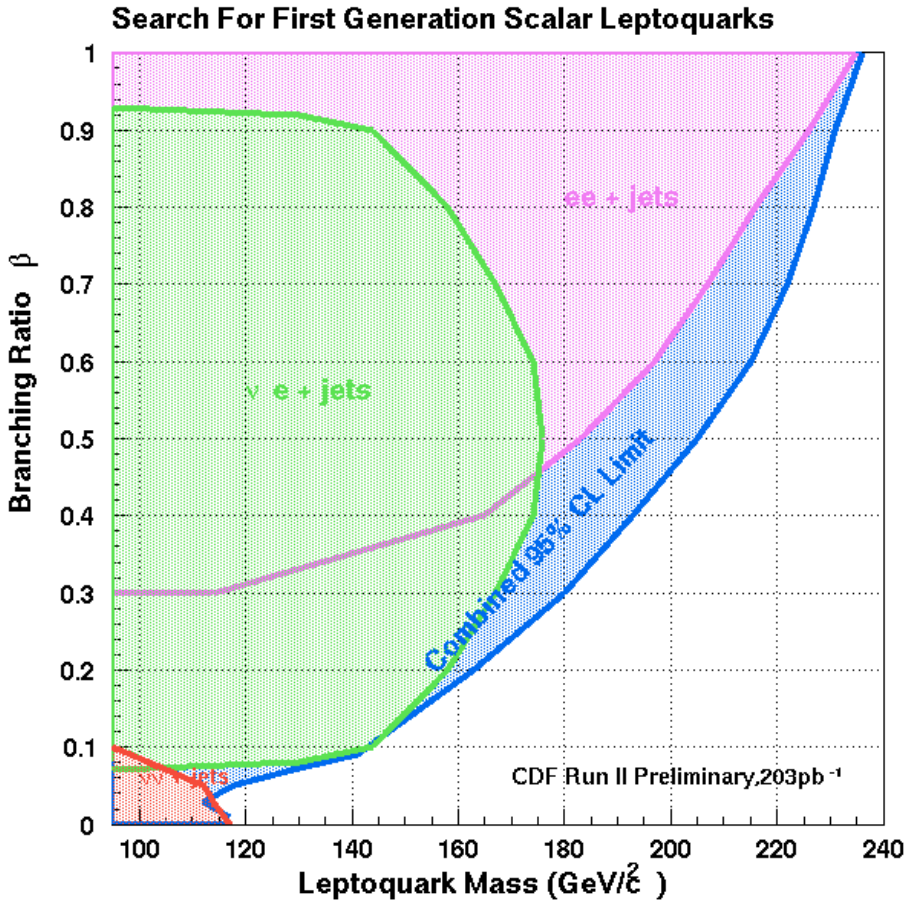
□□jj

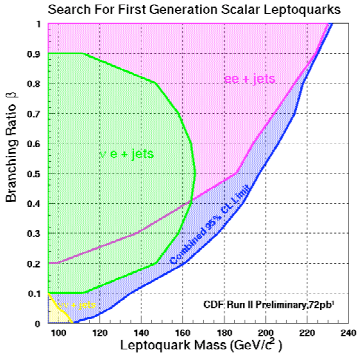


Result: Combination

117GeV/c^2 (β=0.01)
118GeV/c^2 (β=0.05)
145 GeV/c^2 (β=0.1)
164 GeV/c^2 (β=0.2)
205 GeV/c^2 (β=0.5)
236 GeV/c^2 (β=1.0)



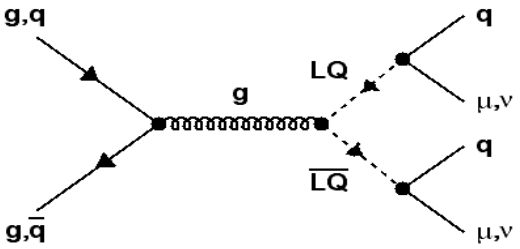




2nd Gen. -- μj μj at CDF

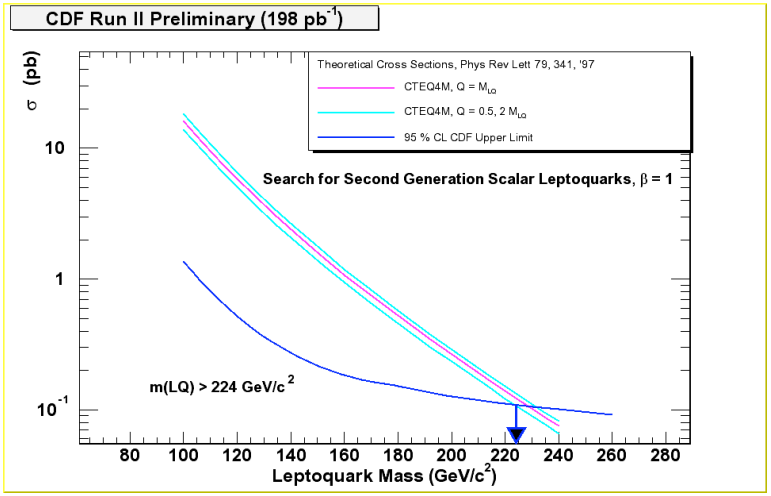
Selection

- 2 muons with $P_T > 25$ GeV
- 2 jets with $E_T(j1,j2) > 30,15$ GeV
- Dimuon Mass Veto:
- $76 < M_{\mu\mu} < 110$, $M_{\mu\mu} < 15$ GeV
- $E_T(j_1) + E_T(j_2) > 85$ GeV and $P_T(\mu_1) + P_T(\mu_2) > 85$ GeV
- $((E_T(j_1) + E_T(j_2))^2 + (P_T(\mu_1) + P_T(\mu_2))^2)^{1/2} > 200$ GeV



Luminosity	$198 pb^{-1}$
Background	2.87 ± 1.0
Observed	2

$M_{LQ} < 224$ GeV/c^2 at 95% CL



2nd Gen - □□jj at CDF

Selection

Z veto (tight/loose pair)

No 2nd muon (CMUP, CMX, or stubless)

$P_T(\mu) > 25$ GeV

$\not\!\!E_T > 60$ GeV

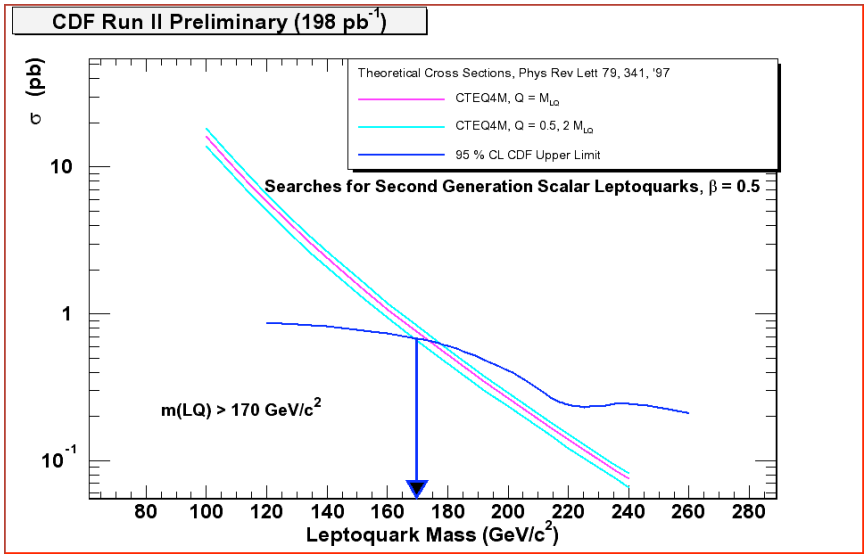
2 jets, @ E_T>30GeV

$\Delta\phi(\mu,\not\!\!E_T)<175°$, $\Delta\phi(\not\!\!E_T,\text{jets})>5°$

$E_T(\text{jet1})+E_T(\text{jet2}) > 80$ GeV

$M_T(\not\!\!E_T,\text{Muon}) > 120$ GeV/c²

Mass Cut



Final Selection

$M_{LQ} < 170$ GeV/c² at 95% CL

	140	160	180	200	220	240	260
W	0.92 ± 0.06	1.44 ± 0.10	1.44 ± 0.10	1.67 ± 0.11	1.65 ± 0.11	0.93 ± 0.06	0.44 ± 0.03
Top	1.69 ± 0.21	1.84 ± 0.23	1.35 ± 0.17	1.00 ± 0.39	0.80 ± 0.29	0.67 ± 0.08	0.52 ± 0.06
Z	0.18 ± 0.01	0.22 ± 0.02	0.19 ± 0.01	0.18 ± 0.01	0.14 ± 0.01	0.05 ± 0.00	0.04 ± 0.00
QCD	0.29 ± 0.29	0.29 ± 0.29	0.29 ± 0.29	0.29 ± 0.29	0.29 ± 0.29	0.29 ± 0.29	0.29 ± 0.00
Total	3.09 ± 0.57	3.74 ± 0.62	3.22 ± 0.56	3.08 ± 0.53	2.83 ± 0.51	1.94 ± 0.44	1.30 ± 0.39
Data	3	3	2	0	0	0	0

Acceptances

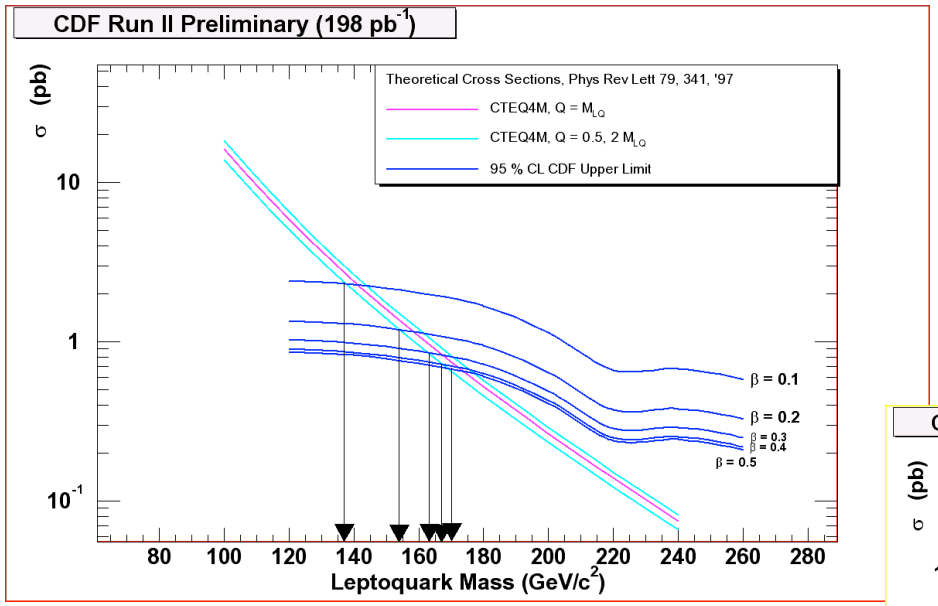
Mass	Acceptance	Relative Error
100	0.0189	0.17
120	0.04	0.09
160	0.13	0.08
180	0.16	0.08
200	0.19	0.08
220	0.22	0.08
240	0.23	0.08

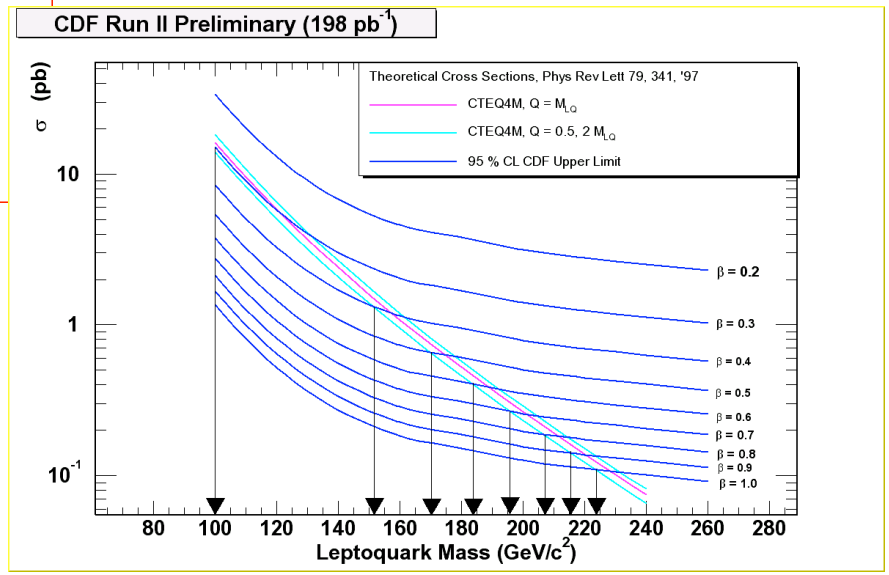
□□jj

□□jj

Mass	Acceptance	Relative Error
100	0.0051	0.47
120	0.073	0.07
160	0.051	0.08
180	0.073	0.08
200	0.094	0.07
220	0.109	0.07
240	0.125	0.07

Results: all □


CDF Run II Preliminary (198 pb^{-1})
Theoretical Cross Sections, Phys Rev Lett 79, 341, '97
CTEQ4M, Q = M_{LQ}
CTEQ4M, Q = 0.5, 2 M_{LQ}
95 % CL CDF Upper Limit
σ (pb)
β = 0.1
β = 0.2
β = 0.3
β = 0.4
β = 0.5
Leptoquark Mass (GeV/c^2)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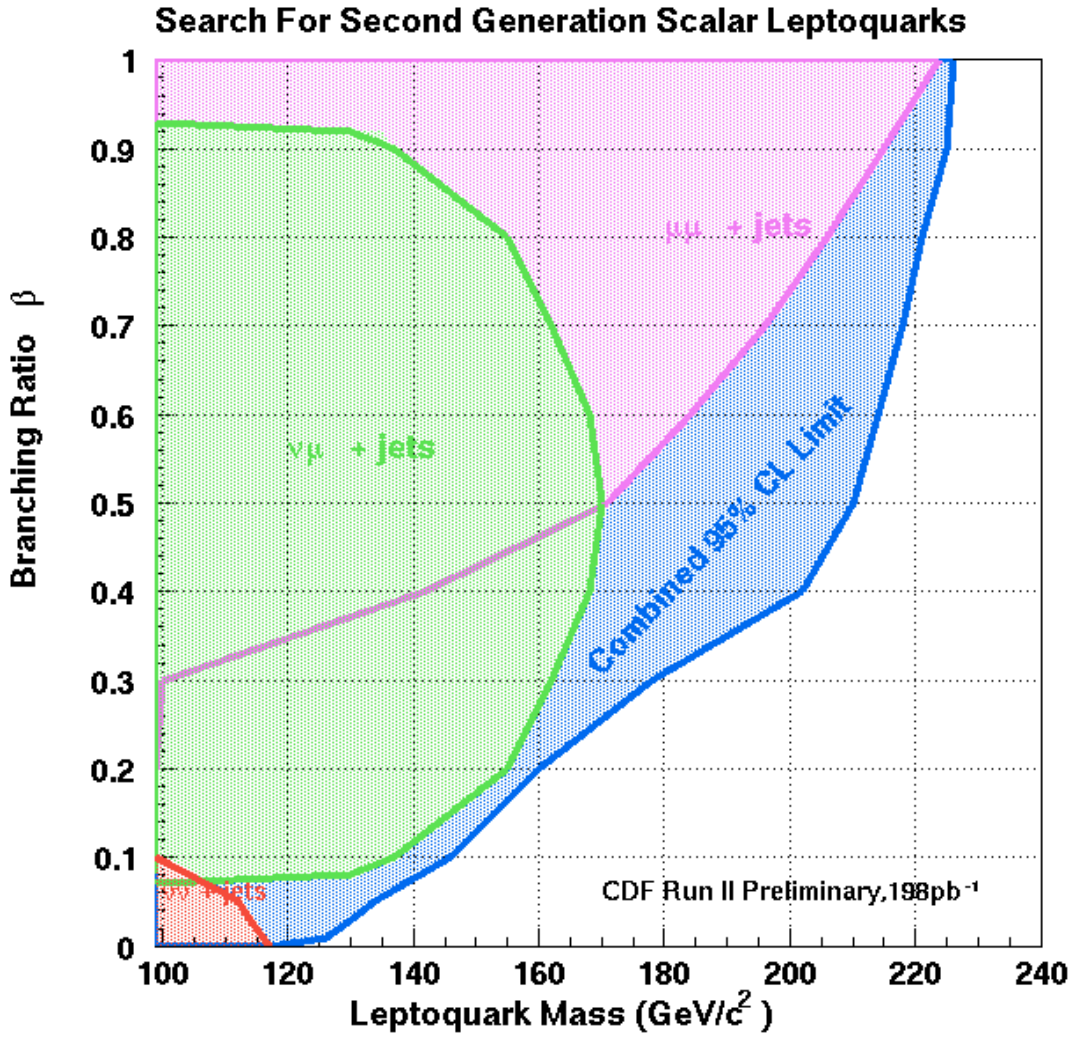
95 % CL CDF Upper Limit
σ (pb)
β = 0.2
β = 0.3
β = 0.4
β = 0.5
β = 0.6
β = 0.7
β = 0.8
β = 0.9
β = 1.0
Leptoquark Mass (GeV/c^2)

2nd Generation combination

126GeV/c^2 (=0.01)
134GeV/c^2 (=0.05)
146 GeV/c^2 (=0.1)
160 GeV/c^2 (=0.2)
210 GeV/c^2 (=0.5)
226 GeV/c^2 (=1.0)



Conclusions

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- We have performed the combination of all the CDF searches for first generation scalar letpoquarks using Run II data.
- The results are combined using a procedure based on a Bayesian approach which takes into account the correlations in the systematic uncertainties.
- We set 95% CL lower limit for scalar first generation leptoquarks at

117GeV/c^2	(β=0.01)
118GeV/c^2	(β=0.05)
145 GeV/c^2	(β=0.1)
164 GeV/c^2	(β=0.2)
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